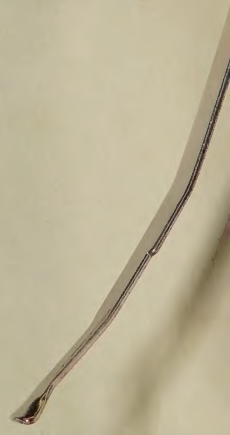
MILLIVAC 952A DC Microvolt-Ammeter

GENERAL ELECTRIC



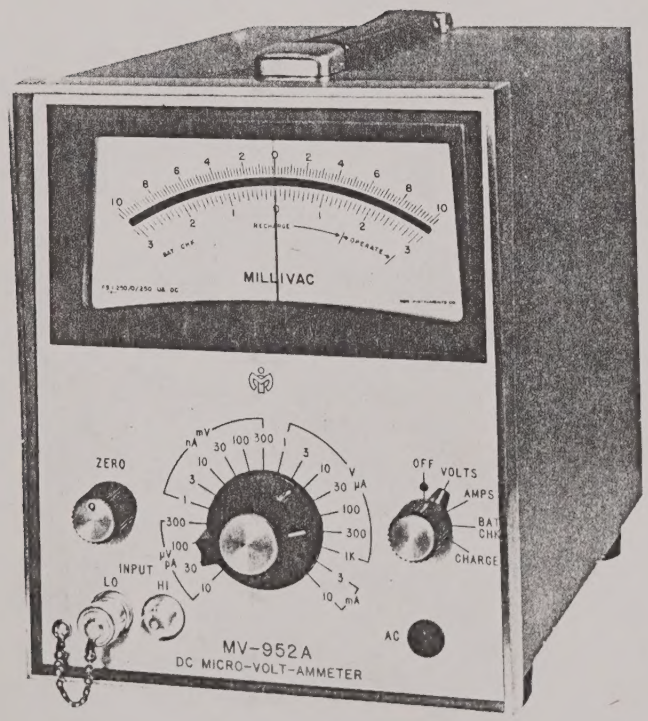
INSTRUCTION MANUAL

TYPE --

MV-952A

DC Micro-Volt-Ammeter

SERIAL NO. 1207



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SPECIFICATIONS

ACCURACY	17 Volt ranges	10μV ±3% FS 30μV ±2% FS 100μV-1000V ±1% FS
	19 Amp ranges	10pA & 30pA ±3% FS 100pA to 10mA ±2% FS
SENSITIVITY		± 10μV FS; ±10pA FS
WARM-UP TIME		30 seconds
RISE TIME		less than 1 second
INPUT IMPEDANCE	Voltmeter	10μV to 3mV - 1 meg 10mV - 2.5 meg 30mV - 5 meg 100 & 300mV - 10 meg 1 V to 1000V - 100 meg
	Ammeter	10pA to 1nA - 1 meg 3nA — 400KΩ decreasing to 0.1Ω on the 10mA range
VOLTAGE DROP		1 mV FS on basic ranges

AMPLIFIER

Hum rejection (at power line freq)	Min. 60 db
Noise	Less than ±1.0μV P-P, referred to input
Drift	negligible
Output Voltage	adjustable from 0 to ±1.0V
Output Current	±1mA @ 1.0V, depending on setting of output potentiometer
Output Impedance	less than 10Ω @ 1.0V, depending on setting of output potentiometer

LEAKAGE	(Floating input to ground)	Min. 1000 meg.
FLOATING MODE OPERATION		May be operated up to 600V DC or 130V AC above ground
METER		Precision "6" taut-band with mirror-backed dial
POWER		Approximately 5 watts at 115/230V AC, 50 - 450 Hz
BATTERY OPERATION		Min. 8 hours after overnight re-charging
DIMENSIONS	Cabinet	9"H, 6-3/4"W, 11-1/2"D
	Rackmount	5-1/4"H, 19"W, 13"D
WEIGHT	Cabinet & Rackmount	13lbs.(net), 15lbs.(shipping)

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SECTION 1

GENERAL DESCRIPTION

1-1 FUNCTION OF THE INSTRUMENT

The MV-952A, DC Micro-Volt-Ammeter, is a compact, lightweight, solid-state instrument. This meter will measure voltages from 10μV to 1000 Volts and current from 10pA to 10mA F.S.

1-2 INSTRUMENT FEATURES

A. No warm-up time or heat rise due to solid-state circuitry
B. Operates on either 115 or 230 V, 50-450Hz
C. Operates on internal, re-chargable batteries
D. "HI" and "LO" input, for selection of chassis grounded or floating operation. (See Section 2, Par. 2-1)
E. May be used as a sensitive null indicator, being a center-zero meter

1-3 POWER LINE REQUIREMENTS

A selector switch is provided on the rear name plate to select either 115 or 230V AC operation. The MV-952A can operate from 50-450Hz. Normally the input hum rejection filter is adjusted to 60Hz unless otherwise specified. For battery operation remove the line cord. Turn Function switch to "Bat. check" position to determine if charging of battery is necessary.

1-4 ACCESSORIES FURNISHED

Three sets of test leads are supplied with the instrument. Two of these leads are identical and interchangeable (Part No. UG-201). The third set, Part No. CL-102, is for the output receptacle only. These test leads utilize solid copper alligator clips to minimize the effect of thermo-electric voltages when measuring low-level DC signals.

1-5 LIST OF INSTRUMENT CONTROLS. (See Fig. 1-1 & 1-2)

A. Front Panel Controls
   1. Function Switch - This serves the dual purpose of turning the instrument on and at the same time selecting the mode of operation, either volts, amps, battery check, or charge.
   2. Range Selector Switch - Enables the operator to select any of the 17 voltage or 19 current ranges.
   3. Mechanical Zero Adjust - Mechanically sets the indicating meter pointer to the Zero Position.
   4. Zero Control - Electrically zeros the instrument.
   5. Pilot Light - Indicates instrument is turned on.
   6. Input Connectors - These are bayonnet type connectors designated as "HI" and "LO" into which the input signal is fed. (See Sec. 2, Par. 2-1)

B. Rear Panel Controls
   1. Output Connector - Furnishes ±1V DC output @ 1.0mA adjustable.
   2. Output Adjust - Varies the output voltage from 0-1V DC.

3. Line Voltage Switch - Selects either 115 or 230V AC operation.
4. Fuse Holder - Contains 0.3 amp "Slo-Blo" fuse.
5. Power Connector - For three conductor AC line cord.
6. Ballast lamp - Current limiting device and battery fuse in charge circuit.

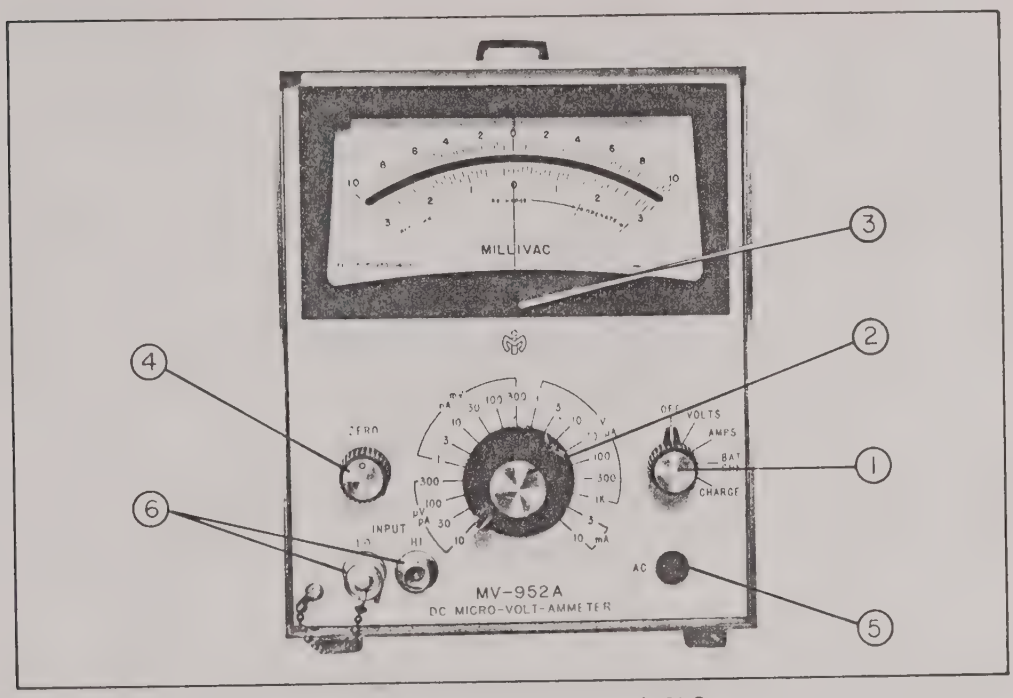


FIG.1-1 FRONT PANEL CONTROLS

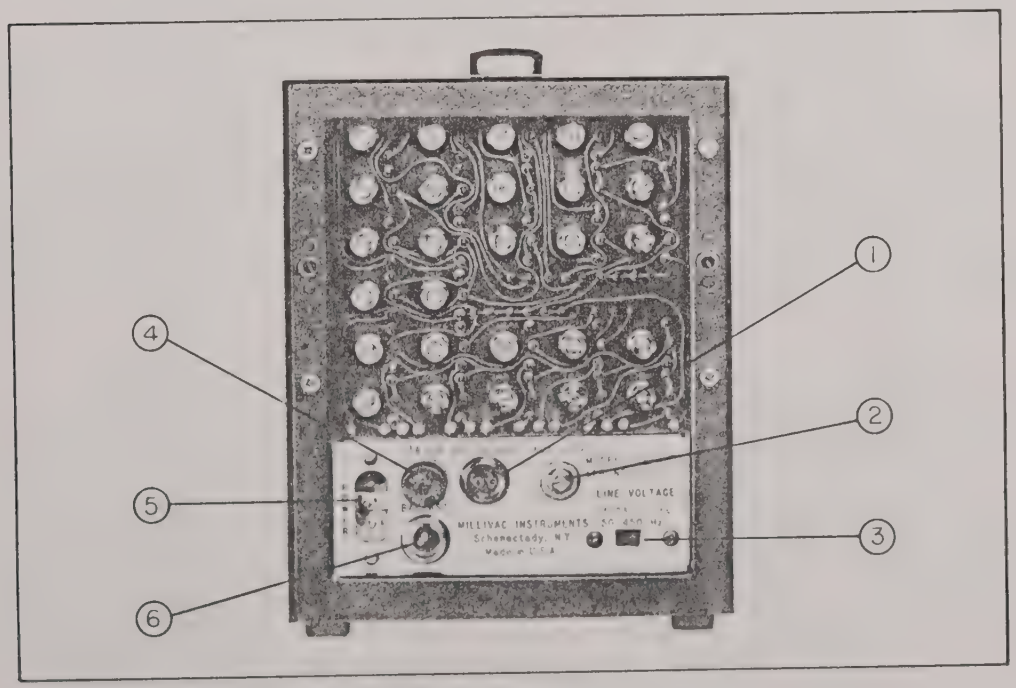


FIG.1-2 REAR PANEL CONTROLS

SECTION 2

OPERATING INSTRUCTIONS

2-1 OPERATION

After unpacking the instrument and accessories, make certain no concealed damage has been incurred during transit. Check that the LINE VOLTAGE slide switch on the rear of the instrument agrees with the local LINE VOLTAGE. If necessary, it can be changed with the aid of a screwdriver. Prior to turning the instrument on, be sure that the pointer on the indicating meter is at the Zero Position. If necessary, adjustment may be made using the Mechanical Zero Adjust. For normal use connect test lead set (Part No. UG-201) to the input connector marked "HI". Put the shorting cap provided on the input connector marked "LO". When making measurements using this input set-up, always make sure that the black lead, which is electrically connected to the housing and chassis of the meter is attached to a signal-grounded point while the red lead is attached to the signal carrying point; otherwise, excessive hum in leads may create erratic readings.

To utilize the floating input characteristics of this instrument, remove the shorting cap from the "LO" input connector and use a UG-201 Test Lead set on each input connector. Short the black coded clips together and use the red coded clips for measurements. Always connect the red coded clip from the "LO" input connector to the point that has the lower potential to ground.

When the desired input connection has been made turn the instrument on by moving the function switch to either volts for voltage measurements, or amps for current measurements. Select the proper range for the measurement to be made and with the voltage or current source de-energized, electrically zero the instrument. The instrument is now ready for use.

2-2 GENERAL PRECAUTIONS

The high sensitivity of the instrument requires certain operating precautions which are not, to the same extent, necessary with less sensitive instruments. Any of the three phenomena described below, or any combination of them, may cause considerable off-sets in the indication of the meter This may easily be mistaken for drifts, noise, or off-sets of the instrument itself, while in reality, the reason may be entirely different. Therefore the following possible sources of errors should be avoided, or their influence minimized as much as possible

A. Thermo-Electric voltages. They are parasitic voltages created through temporary or permanent temperature differences between the various junctions in the measuring circuit, both inside and outside the meter. When calibrating the meter on its more sensitive ranges, or when checking its calibration on these ranges, it is important that the following procedure be observed: Connect the meter to the voltage divider point expected to supply the exact voltage, but leave the power to this divider de-energized until the meter has been carefully zeroed. Then turn the power on and observe the deflection. An alternative, but wrong procedure, would be to have the attenuator energized before the meter is connected to the signal source and zeroing the instrument with its input terminals shorted. If thermo-electric voltages exist after connecting the terminals of the instrument to the voltage divider,

they would falsify the calibration signal. Therefore, the first method should always be used.

In order to reduce the possibility of thermo-electric voltage errors, the input circuitry of the instrument was designed with special precautions. The input cables have solid copper alligator clips, so that no thermo voltages will be created in the copper wire-alligator clip junction. However, the user must avoid creating additional thermo-couples in the circuitry under test by carefully avoiding any dissimilar metal connections.

B. Hum Signals. Any hum signal will have a tendency to create measuring errors if it is superimposed upon DC voltages to be measured. In order to reduce this error to a minimum, an effective hum rejection filter in the input circuit reduces this source of measuring error considerably. The rejection by this filter to hum signals is approximately 60db. As a simple rule, it can be said that a certain DC signal, superimposed by an identical amount of AC pick-up, will be read with an error of less than $\pm$0.1%. Nevertheless, large AC signal content should be avoided when making DC measurements. The hum rejection is further increased on voltage ranges above 1mV, due to the resistive divider, which drops any DC voltage to be measured to a basic sensitivity of 1mV. For instance, in the 1KV measuring range, the hum rejection is 120db in addition to the basic 60db, or a total of approximately 180db. On the current ranges, the 60db hum rejection remains constant on all ranges.

C. Input Overload. Excessive overload may result in damage to the input circuit. Make certain that the values listed below are not exceeded. Maximum potential difference between panel and floating ground must not exceed 600V DC.

TABLE 1 - Maximum Allowable Overload

Voltage Range	Max. Input - Volts
10μV thru 1mV	50V
3mV	125V
10mV	500V
30mV	1250V
100mV thru 1000V	1500V

Current Range	Max. Input - mA
10pA thru 1nA	.05mA
3nA	.125mA
10nA	.5mA
30nA	1.25mA
100nA	5.0mA
300nA	10mA
1μA	20mA
3μA	30mA
10μA	60mA
30μA	100mA
100μA	200mA
300μA	300mA
1mA	600mA
3mA	1A
10mA	1A

SECTION 3

DESCRIPTION OF CIRCUITRY

3-1 GENERAL

The basic circuitry of the instrument is best understood by reference to the block diagram, Fig. 3-1.

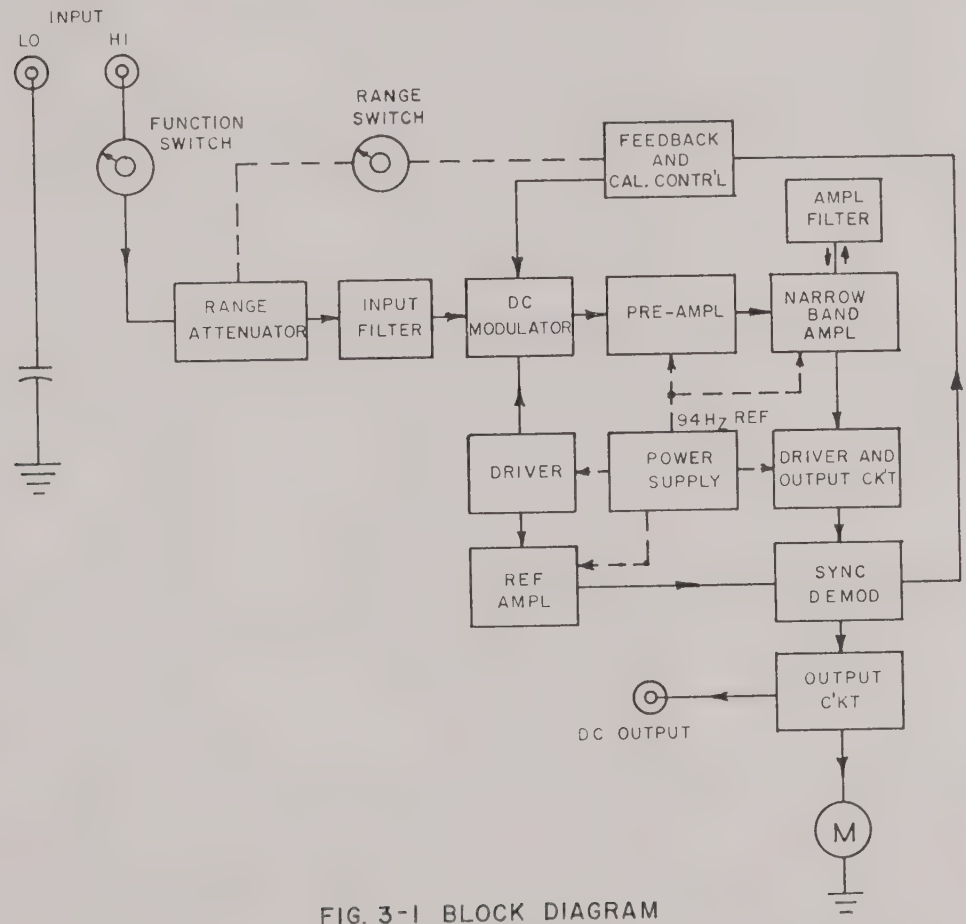


FIG. 3-1 BLOCK DIAGRAM

The DC signal after passing through the function switch and the attenuator section of the range selector switch goes to the Input Filter, for rejection of power line frequency components which might cause a measuring error. A single-pole, double-throw DC Modulator converts the incoming DC signal into a nearly symmetrical square wave. The converted signal is then impedance-matched and amplified by a high impedance Pre-Amplifier. The output from the Pre-Amplifier is fed into the Narrow Band Amplifier, where its narrow band-width improves the signal-to-noise ratio of the instrument. The output of this stage is further amplified in the Driver and push-pull Class B Output stage. Next, the AC signal is rectified by a Synchronous Demodulator and the resultant DC output is used to provide heavy overall DC feedback. The DC output is also used to drive the

indicating meter. The DC Modulator is driven by a 2-transistor multi-vibrator circuit operating on 14.4 volts from the Power Supply.

The DC Modulator and its Driver determine the carrier frequency (in the order of 94Hz). The square wave output voltage of the Driver is sampled and amplified by the Reference Amplifier whose output is fed to the Synchronous Demodulator. The phase relationship between the Reference Amplifier signal and the carrier amplifier signal determine the polarity of the DC output. An electronically regulated Power Supply delivers 14.4 volts to the amplifier.

NOTE: For the following detailed description of each circuit block, reference should be made to the complete circuit schematic for this instrument, attached at the end of this manual.

3-2 INPUT CIRCUIT AND FUNCTION SWITCH

The input signal passes from the input connectors via shielded cable to the function switch, S102. The function switch will then select the proper section of the range selector switch, either the voltage divider for voltage measurements or the current shunts for current measurements.

3-3 RANGE SELECTOR SWITCH

The range selector switch, S101, consists of 7 sections, A through G. Sections A, B, C, D and E select the proper divider or shunt for each range. Sections F and G select the proper DC feedback ratios for the volt ranges and current ranges, respectively.

3-4 INPUT FILTER

This consists of an R/C network providing an effective AC filter with a minimum of 60db rejection at power line frequency.

3-5 DC MODULATOR (G201)

A 94Hz printed circuit plug-in DC modulator is employed. It modulates the DC input signal and the resultant AC component is impedance matched by the input transformer T201.

3-6 PRE-AMPLIFIER (A301)

This 50db gain Pre-Amplifier features a low-noise, high-impedance input achieved by the use of a high quality low-noise field effect transistor (Q301). Diodes CR301 and CR302, form a clamp circuit to protect the input transistor from excessive overload. A three-stage conventional R/C coupled, common-emitter amplifier consisting of Q302, 303, and 304 with the input transistor Q301 develops an open loop gain of approximately 60db A 10db overall AC feedback loop results in an amplifier with very good gain stability and transistor interchangeability. The supply voltage is held at -5.8 volts by zener diode CR305

3-7 NARROW BAND AMPLIFIER AND AMPLIFIER FILTER

The Narrow Band Amplifier improves the signal-to-noise ratio by reducing the amplifier bandwidth. It consists of transistors Q201, 202 and 203. Q201 is a common-emitter circuit with a parallel "T" network dynamically tuned to 94Hz in a negative feedback loop from collector to base. Q202 is an emitter follower, providing impedance matching between the "T" filter and the base of Q201. Q202 also provides isolation and impedance matching to the next stage. The "T" filter exhibits high impedance at its resonant frequency rapidly decreasing at off-resonance points. With this filter in series with the negative feedback loop, a selective amplifier results with maximum output occurring at filter resonant frequency.

3-8 DRIVER AND OUTPUT CIRCUIT

The driver (Q204) and the Class B output stage (205 and 206) are conventional transformer-coupled stages. The Amplifier Gain Control, R211 is located in the driver-emitter circuit and controls the amount of degeneration developed at this stage by the position of capacitor C205 on the emitter resistor. The signal developed in the output stage is applied to the Synchronous Demodulator, where rectification takes place. Before discussing this stage, an explanation of the DC Modulator Driver and Reference Amplifier is in order.

3-9 DC MODULATOR DRIVER (A204)

The Modulator Driver is an encapsulated plug-in module consisting of a two-transistor multi-vibrator circuit. The characteristics of the MODULATOR and DRIVER combination determine the 94Hz carrier frequency.

3-10 REFERENCE AMPLIFIER

The square wave output of the DC Modulator Driver is sampled by the Reference Amplifier via transformer T204. This amplifier consisting of Q209, 210 and 211, is similar to the driver and output stage previously described and is used to develop a reference signal for the Synchronous Demodulator for correct rectification of the output signal.

3-11 SYNCHRONOUS DEMODULATOR

Q207 and 208 are utilized in this phase-sensitive rectifying circuit. The signal from the output stage (205 and 206) is compared with the reference signal from Q210 and Q211. The resultant DC output signal from the demodulator has a polarity corresponding to the original input signal polarity. In this type of operation, the collector current is a function of the collector voltage only and is essentially independent from other transistor parameters. The voltage applied to the base of the transistor acts only as a phase-sensitive reference.

3-12 DC FEEDBACK AND CALIBRATION CONTROLS

A portion of the DC output voltage is fed back to the modulator input circuit to provide the excellent gain stability of the instrument. This feedback ratio is determined by values of the series resistance, connected through Sections F and G of the range selector switch. An individual calibration control for each voltage range and for most of the current ranges is also a part of the feedback loop selected by these sections. The appropriate feedback ratio is auto-

matically selected when the range is chosen. The screwdriver adjusted controls are mounted on an internal panel. They are easily accessible from the rear of the instrument and are readily identified. They are properly set at the factory when the instrument is calibrated. If it becomes necessary to re-calibrate the instrument, the controls may be easily adjusted to restore the rated accuracy.

3-13 METER CIRCUIT

The indicating meter is rated at 250-0-250μA DC. It is connected to the output of the Synchronous Demodulator through a 4.2K series Resistor, R427, making the total meter circuit resistance approximately 4,500 ohms. An output signal of approximately 1V will drive the meter to full scale. Output filtering is provided by capacitors C401 and C402.

3-14 REGULATED POWER SUPPLY

The electronically regulated power supply includes a 115/230V AC split primary power transformer (T601). Its secondary, in conjunction with the rectifiers (CR601, CR602), is used in a full-wave, center-tapped configuration. The rectifier output is applied to the collector of the series regulator transistor Q601. The base of Q601 is biased by the temperature stable reference amplifier (Q602). The regulated output voltage appears at the emitter of Q601. An adjustable voltage divider across the output, consisting of R606, 608 and potentiometer R607, permits adjustment of the output voltage by determining the bias of the transistor portion of Q602.

SECTION 4

CALIBRATION

4-1 GENERAL

The instrument, although being rated as ±1% of full scale, is calibrated at the factory to a much better accuracy. This is possible due to the fact that most Millivac instruments are provided with a calibration control for each range. These controls facilitate quick and accurate re-calibration and compensate for minor errors due to the possible aging of attenuators or other components. Complete in-cabinet calibration may be made after the removal of the cover plate on the rear of the cabinet.

4-2 CALIBRATION PRECAUTIONS

As mentioned in Section 2-2, in order to avoid mis-calibration of the instrument, extra precautions must be taken. The meter should be zeroed only with the calibrator output attached to the input of the instrument while the calibrator is de-energized. This procedure should be followed for both the voltage and the current calibration. Zeroing the meter first and then connecting it to the calibrator may introduce calibration errors.

4-3 VOLTAGE CALIBRATION PROCEDURE

Mechanical zero adjustment should always be the first step in calibration. Before any electrical calibration adjustments are made, a warm-up period of 5 to 10 minutes is recommended.

After the correct voltage for individual ranges has been applied, re-adjust, if necessary, the individual controls marked accordingly. After this procedure has been repeated for all the ranges, check the linearity of the meter on any one of the basic feedback ranges (1mV or above) by applying 100%, 90%, 80%, 70%, 60%, 50%, 40%, 30%, 20% and 10% of the signal at a given range. The meter should indicate the same percentage of the reading within the rated accuracy of the meter (±1% of full scale).

4-4 CURRENT CALIBRATION PROCEDURE

After applying the correct current for each range, adjust the controls for the individual ranges accordingly. In the instrument, the 10pA, 30pA, 100pA, 300pA and 1mA have individual calibration controls, while the ranges from 3nA through 300μA have one common control. This is the reason why the current ranges are rated as being 2% of full scale, although the ranges with individual controls can be adjusted to better than 1% accuracy.

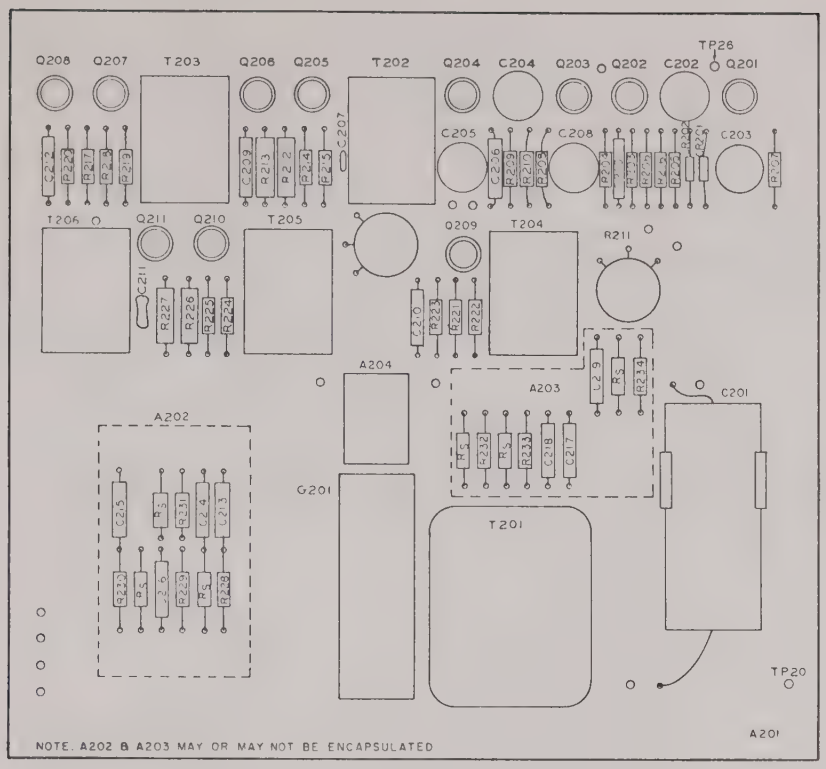


Fig. 5-1 Main Amplifier Board Assembly

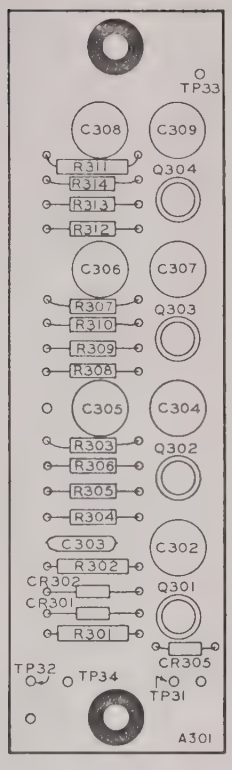


Fig. 5-2 Pre-Ampl Board Ass'y

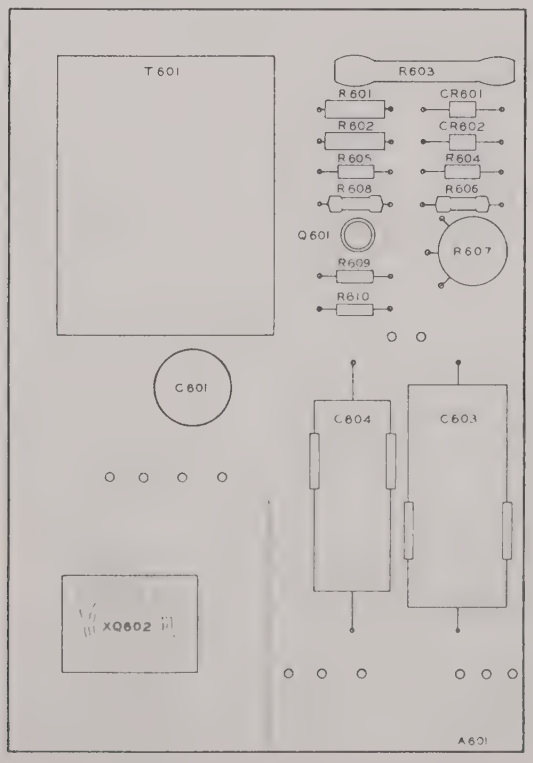


Fig. 5-3 Power Supply Board Assembly

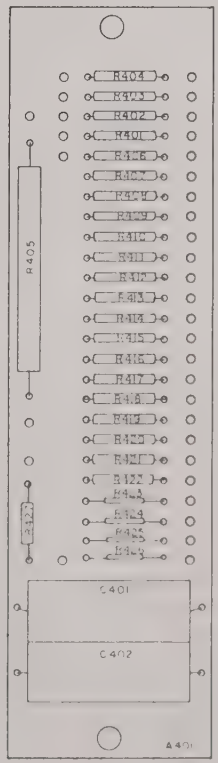


Fig. 5-4 Input-Output Board Assembly

SECTION 5

MAINTENANCE

5-1 GENERAL

The following sections describe the usual maintenance procedure for the instrument.

5-2 MAINTENANCE OF THE INSTRUMENT

5-2.1 Cabinet Removal

Should the instrument require repairs which necessitate its removal from the cabinet, remove the rear calibration cover plate exposing 4-flat head Phillips 6-32 screws. Upon removing these screws slide the cabinet to the rear and off the instrument

5-2.2 General Trouble-Shooting

If the instrument fails to turn on, check the line cord and fuse. The fuse is located on the rear nameplate and should be replaced only with a 0.3A "Slo-Blo" type fuse.

If the instrument is not functioning properly and requires trouble-shooting, the DC Modulator, Driver, and transistors should be check first, preferably by substitution. When checking the transistors by substitution, replace only with units of the same type and manufacture. Transistor Q301 may be ordered directly from Millivac, as well as the DC Modulator G201 and Driver A204. When the instrument is turned on, the Modulator should produce a continuous audible 94Hz tone. If no tone is evident, the Modulator or its Driver may be defective. Figs. 5-1, 5-2, 5-3, and 5-4 will be helpful in identifying and locating the various components of the instrument. Important static-voltage values and waveshapes with peak-to-peak voltage values are shown on the circuit schematic.

5-2.3 Signal Tracing

Assuming that a routine investigation by substitution has confirmed that the DC Modulator, its Driver, and all transistors are good, signal tracing is the next approach

Recommended service equipment consists of:

1 - DC VTVM, Millivac MV-864A or MV-964A or equal
1 - Tektronix Model 503 scope or equal
1 - AC VTVM (RMS), Millivac MV-45A or equal

When operating the instrument removed from its cabinet, care must be exercised in avoiding power line hum pick-up in the modulator and preamplifier

circuits. Excessive pick-up will prevent making useful gain and waveshape measurements. If pick-up is a problem, aluminum plates placed on the bottom, top, and amplifier side of the instrument will effectively shield the instrument

Be certain that the power supply voltage is set at 14.4 volts before making any gain measurements, or variations may result.

A. Checking Waveshape of Complete Amplifier. If the meter is operative at all, although somewhat erratic or intermittent, improper modulator action or other amplifier weaknesses may be detected by observation of the chopped and amplified signal at the secondary winding of the output transformer test point, TP21 or TP23 and chassis ground. (See circuit schematic of main amplifier). A check of the output waveshape can be made by feeding a 10μV, D.C. signal into the input with the range switch in the 10μV position and the Function Switch in the Volts position. Without the input signal and the instrument properly zeroed, the wave shape appears as shown in the circuit schematic of the main amplifier. The residual signal appearing in the zero-signal wave shape is not entirely amplifier noise. Its spikes and depressions are caused by the 94Hz reference signals impressed upon the bases of Q207 and Q208. Any drastic deviations of either wave shape indicates a faulty amplifier. Improper adjustment of the zero control may result in large deviations from the wave shapes illustrated.

The reference amplifier output signal must be of the correct amplitude and wave shape for proper operation. The wave shape can be observed across TP24 and TP25. If the scope is tied to the power line, the instrument should be isolated from ground. The waveshape and amplitude should agree closely with that shown on the Reference Amplifier schematic.

B. Checking Modulator and Pre-Amplifier Stages. Locate test point, TP33, on pre-amplifier board (See Fig. 5-2) and unsolder the brown lead connected to it. This disconnects the output of the pre-amplifier from the main amplifier. The wave shape of the amplified, chopped signal at TP33, can be observed, as seen on the pre-amplifier circuit schematic. After unsoldering the brown lead, but before making this wave shape measurement adjust the galvanometer to Zero, using the Zero Control.

Two wave shape values are shown. One is with zero input signal while the other is with a 10μV DC signal applied to the input. With 10μV DC input, the output of the pre-amplifier should be approximately 50mV, peak-to-peak at 94Hz and should be essentially a square wave. Any drastic deviation in amplitude and wave shape indicates an abnormality in this portion of the instrument Transistors are checked best by substitution. Be certain to replace only with units of the same type and manufacture.

C. Checking the Main Amplifier. With the amplifier set-up as in 5-2.3B feed signal from test set-up, shown in Fig. 5-5, which furnishes the necessary input signal to drive the meter to full scale in the 10μV position. In making this measurement, the reference amplifier must be functioning properly with the correct output amplitude and waveshape, as shown on main amplifier schematic. With the test source switched off, carefully adjust the Zero Control to zero the instrument. Now switch on

the test source, supplying the correct input signal to the main amplifier via TP26. (See Fig. 5-1). The meter should now slowly move upscale and if the amplifier has the correct gain the meter will read approximately full scale. If the reading is in error by more than ±10% of full scale, the amplifier gain control, R211, can be adjusted for a full scale meter reading. This adjustment should occur at a point between 25% and 75% of the control's rotation.

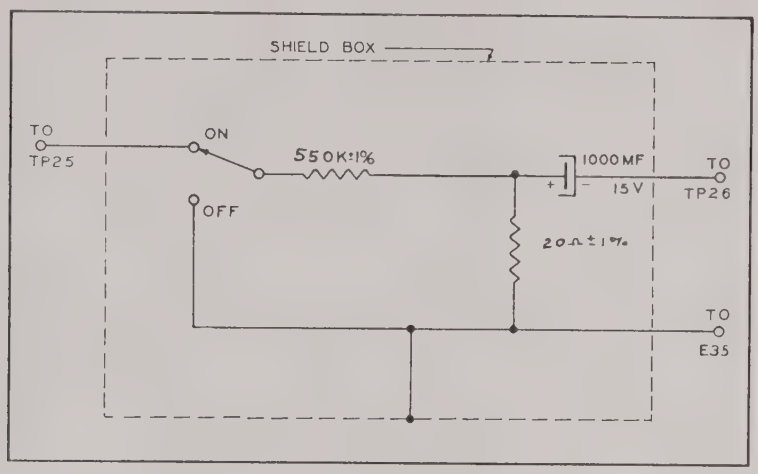


Fig. 5-5 Test Set-Up

If excessive gain is necessary or the meter cannot be made to read full scale it indicates a faulty amplifier and the transistors in the associated circuit should be checked. It is important to replace only with the same type and manufacture.

When the above adjustments are correct the instrument can be restored to its normal condition by re-soldering the brown lead to test point TP33. The instrument's calibration should now be checked before placing it back in service.

5-2.4 Modulator and Driver (Removal - Replacement)

A printed circuit plug-in type modulator and driver are employed in this circuit. They must be replaced only by units of the same type and manufacture. It is recommended that they be obtained from Millivac, where they are tested and checked for performance in Millivac Instruments. The modulator is secured by a hex nut accessible on the printed circuit side of the board directly underneath the modulator. The driver is secured by a hold-down clip. It is only necessary to loosen the screw holding the clip to the board. The clip may now be rotated away from the driver, allowing it to be removed from the board. Care must be exercised when removing these units so as to prevent bending of the pins. Be certain to properly secure these units when re-installing on the board.

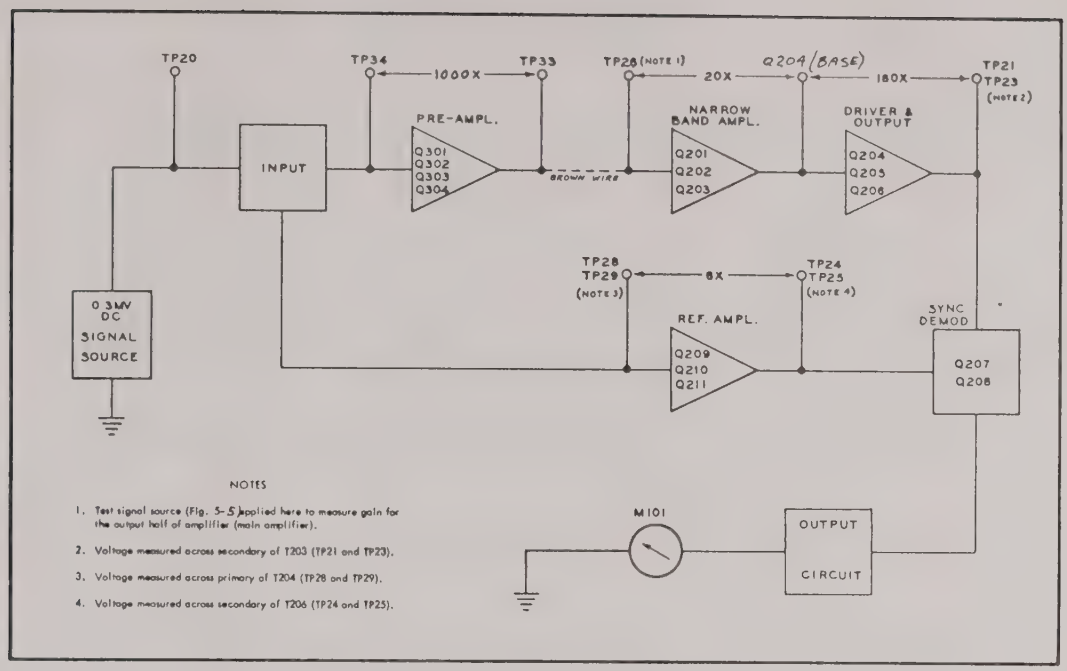


Fig. 5-6 Amplifier Gain Diagram

5-2.5 Power Supply

A. Line Operation. The output of the power transformer T601 is rectified by diodes CR601 and CR602 in a full wave center-tapped configuration. The resultant DC is limited by R603 and regulated by the series transistor Q601. The adjustable voltage divider R606, R608, and potentiometer R607, sets the bias on the voltage Reference Amplifier Q602, whose output controls the bias on Q601, the series regulator. The output of the power supply can be varied from approximately 11 volts to 18 volts by R607. With the instrument as the only load (approximately 95mA) and the voltage set to 14.4 volts, the power supply should regulate with as little as approximately 80 volts AC input. When measuring the power supply ripple with an oscilloscope, be certain the line voltage is near 117 volts AC. The ripple voltage wave shape is shown on the Power Supply schematic. The scope should be connected to TP61 with the ground connection at power supply ground test point.

B. Battery Operation. The internal nickel-cadmium batteries are trickle charged during normal line operation of the instrument. The instrument will operate a minimum of 8 hours and it can be re-charged overnight. Many charges, and re-charges can be performed. Warning: Do not allow the batteries to discharge below the "operate" point on the meter scale.

SECTION 6

REPLACEABLE PARTS LIST

CKT SYM	Description	Millivac Part No.	Manufacturer & Mfr's. Part No.
A1 thru			
A200	Not assigned		
A201	Ass'y, etched circuit board, Main Amplifier	450-1011B	
A202#	Ass'y, Input filter	450-1007	
A203#	Ass'y, Amplifier filter	450-1008	
A204	Ass'y, DC Modulator Driver (94Hz)	700-1006	
A205 thru			
A300	Not assigned		
A301	Ass'y, etched circuit board, Pre-amplifier	450-1026A	
A302 thru			
A400	Not assigned		
A401	Ass'y, etched circuit board, Input-Output	450-1046A	
A402 thru			
A500	Not assigned		
A501	Ass'y, etched circuit board, Calibration controls	450-1045B	
A502 thru			
A600	Not assigned		
A601	Ass'y, etched circuit board, Power Supply	450-1017D	
BT1 thru			
BT100	Not assigned		
BT101+	Ass'y, Battery	460-1000	
C1 thru			
C100	Not assigned		
C101	Capacitor, paper, Mylar, .47μfd, 600V	621-1008	Mallory PVC6047
C102 &			
C103	Not assigned		
C104 &			
C105	Capacitor, ceramic, disc, .01μfd, 1000V	610-1017	Centralab C1-103
C106 thru			
C200	Not assigned		
C201	Capacitor, electrolytic, 2000μfd, 12V	635-1023	Sprague 31D120
C202	Capacitor, electrolytic, 100μfd, 16V	635-1017	Sprague 89D217
C203 thru			
C205	Same as C202		
C206 &			
C207	Capacitor, ceramic, disc, .002μfd, 1000V	610-1006	Centralab DD-202
C208	Same as C202		
C209	Capacitor, paper, metalized, 0.1μfd, 200V	630-1002	Hopkins P12D
C210	Same as C206		
C211	Capacitor, ceramic, 200μμfd, 600V	600-1003	Centralab D6-221
C212	Capacitor, paper, metalized, 0.1μfd, 400V	630-1019	Hopkins P14D

#May or may not be an assembly, as an assembly use its part number where replacing
+Used in Model MV-952A only.

CKT SYM	Description	Millivac Part No.	Manufacturer & Mfr's. Part No.
C213	Capacitor, paper, metalized, 0.22µfd, 100V ±2% (Part of A202 if it is an ass'y)	630-1017	Midwec 7F
C214 & C215	Capacitor, paper, metalized, 0.15µfd, 100V ±2% (Part of A202 if it is an ass'y)	630-1015	Midwec 7F
C216	Capacitor, paper, metalized, 0.3µfd, 100V ±2% (Part of A202 if it is an ass'y)	630-1018	Midwec 7F
C217 & C218	Capacitor, paper, metalized, 0.1µfd, 100V ±1% (Part of A203 if it is an ass'y)	630-1020	Midwec 7F
C219	Capacitor, paper, metalized 0.2µfd, 100V ±1% (Part of A203 if it is an ass'y)	630-1016	Midwec 7F
C220 thru C301	Not assigned		
C302	Same as C202		
C303	Same as C209		
C304 thru C309	Same as C202		
C310 thru C400	Not assigned		
C401 & C402	Capacitor, electrolytic, 1000µfd, 12V	635-1021	Sprague 31D118
C403 thru C600	Not assigned		
C601A&B	Capacitor, electrolytic, 250-250µfd, 50V	635-1016	Sprague D71685
C602	Not assigned		
C603	Capacitor, electrolytic, 2000µfd, 16V	635-1024	Sprague 31D132
C604	Capacitor, electrolytic, 1000µfd, 16V	635-1022	Sprague 31D130
CR1 thru CR100	Not assigned		
CR101+	Diode, 1N2482	101-2000	Sarkes 1N 2482
CR102 thru CR200	Not assigned		
CR201& CR202	Diode, 1N198	101-0198	Hughes 1N198
CR203 thru CR300	Not assigned		
CR301 & CR302	Diode, 1N816	101-2003	Transitron 1N816
CR303 & CR304	Not assigned		
CR305	Diode, zener 1N706	101-2001	Hoffman 1N706
CR306 thru CR600	Not assigned		
CR601 & CR602	Diode, 1N2482	101-2000	Sarkes 1N2482

+Used in Model MV-952A only.

CKT SYM	Description	Millivac Part No.	Manufacturer & Mfr's. Part No.
DS1 thru			
DS100	Not assigned		
DS101	Lamp, pilot AC	800-3001	Drake R118-604
F1 thru			
F100	Not assigned		
F101	Fuse, cartridge, S-B, 3/10 AMP	800-1006	Bus-MDL
G1 thru			
G200	Not assigned		
G201	Chopper, electro-mechanical, S.P.D.T., 94Hz	700-1008	
J1 thru			
J100	Not assigned		
J101	Connector, BNC, female, INPUT	800-7030	UG-657/U
J102	Same as J101		
J103	Connector, Output	800-6060	Amphenol 80PC2F
J104	Connector power, male, 3 pin	800-7406	Tower H1061
M1 thru			
M100	Not assigned		
M101	Meter, indicating, 250-0-250μA (852A)	203-1118	
	Meter, indicating, 250-0-250μA (952A)	203-1119	
P1 thru			
P103	Not assigned		
P104	Cord set, line, power, removable	800-5121	Belden 17258S
P105	Part of P104		
Q1 thru			
Q200	Not assigned		
Q201	Transistor, Ge, PNP, 2N414	100-1004	Industro 2N414
Q202 &			
Q203	Same as Q201		
Q204	Transistor, Ge, PNP, 2N1414	100-1008	GE 2N1414
Q205 thru			
Q211	Same as Q204		
Q212 thru			
Q300	Not assigned		
Q301	Transistor, Si, NPN	100-1005	
Q302 thru			
Q304	Same as Q201		
Q305 thru			
Q600	Not assigned		
Q601	Transistor, Ge, PNP, 2N459A	100-1009	Motorola 2N459A
Q602	Transistor, Si, RA1	100-1010	GE RA1
R1 thru			
R100	Not assigned		
R101	Resistor, variable, comp, linear taper, 1meg ±20%, 1/2W	580-1030	
R102	Resistor, fxd, comp, 620K ±10%, 1/2W	500-624	

CKT SYM	Description	Millivac Part No.	Manufacturer & Mfr's. Part No.
R103	Resistor, variable, comp, lin. taper, 5K ±20%, 1/2W	580-1011	
R104+	Resistor, fxd, metal film, 55K ± 1%, 1/4W	512-5502	
R105 thru R200	Not assigned		
R201	Resistor, fxd, WW 25Ω ±1%, 1/2W	520-25ROW	
R202	Resistor, fxd, metal film, 17.7K ± 1%, 1/4W	512-1772	
R203	Resistor, fxd, comp. 3.3K ± 10%, 1/2W	500-332	
R204	Resistor, fxd, comp. 82K ± 10%, 1/2W	500-823	
R205	Resistor, fxd, comp, 10K ± 10%, 1/2W	500-103	
R206	Same as R205		
R207	Resistor, fxd, comp, 820Ω ± 10%, 1/2W	500-821	
R208	Same as R205		
R209	Same as R205		
R210	Same as R204		
R211	Resistor, variable, carbon, lin. taper, 1K ±30%, 1/4W	580-1018	
R212	Resistor, fxd, WW, 8.2Ω ±10%, 1/2W	510-8R2	
R213	Same as R212		
R214	Resistor, fxd, comp., 47Ω ±10%, 1/2W	500-470	
R215	Resistor, fxd, comp., 4.7K ±10%, 1/2W	500-472	
R216	Resistor, fxd, comp., 27Ω ±10%, 1/2W	500-270	
R217	Same as R204		
R218	Same as R204		
R219	Resistor, fxd, comp., 27K ±10%, 1/2W	500-273	
R220	Same as R219		
R221	Resistor, fxd, comp., 1K ±10%, 1/2W	500-102	
R222	Resistor, fxd, comp., 8.2K ±10%, 1/2W	500-822	
R223	Same as R221		
R224	Same as R215		
R225	Same as R216		
R226	Resistor, fxd, WW, 2.2Ω ±10%, 1/2W	500-2R2	
R227	Same as R226		
R228	Resistor, fxd, metal film, 20K ±1%, 1/4W (Part of A202 if it is an ass'y)	512-2002	
R229*& R230*	Resistor, fxd, metal film, 17.7K ±1%, 1/4W -- (Part of A202 if it is an ass'y)	512-1772	
R231*	Resistor, fxd, metal film, 8.85K ±1%, 1/4W -- (Part of A202 if it is an ass'y)	512-8851	
R232*& R233*	Resistor, fxd, metal film, 16.9K ±1%, 1/4W -- (Part of A203 if it is an ass'y)	512-1692	
R234*	Resistor, fxd, metal film, 8.47K ±1%, 1/4W (Part of A203 if it is an ass'y)	512-8471	
R235 thru R300	Not assigned		
R301	Resistor, fxd, metal film, 10Ω ±1%, 1/4W	512-10R0	

*Resistor may be shunted by another resistor; value selected in manufacture.
+Used in Model MV-952A only.

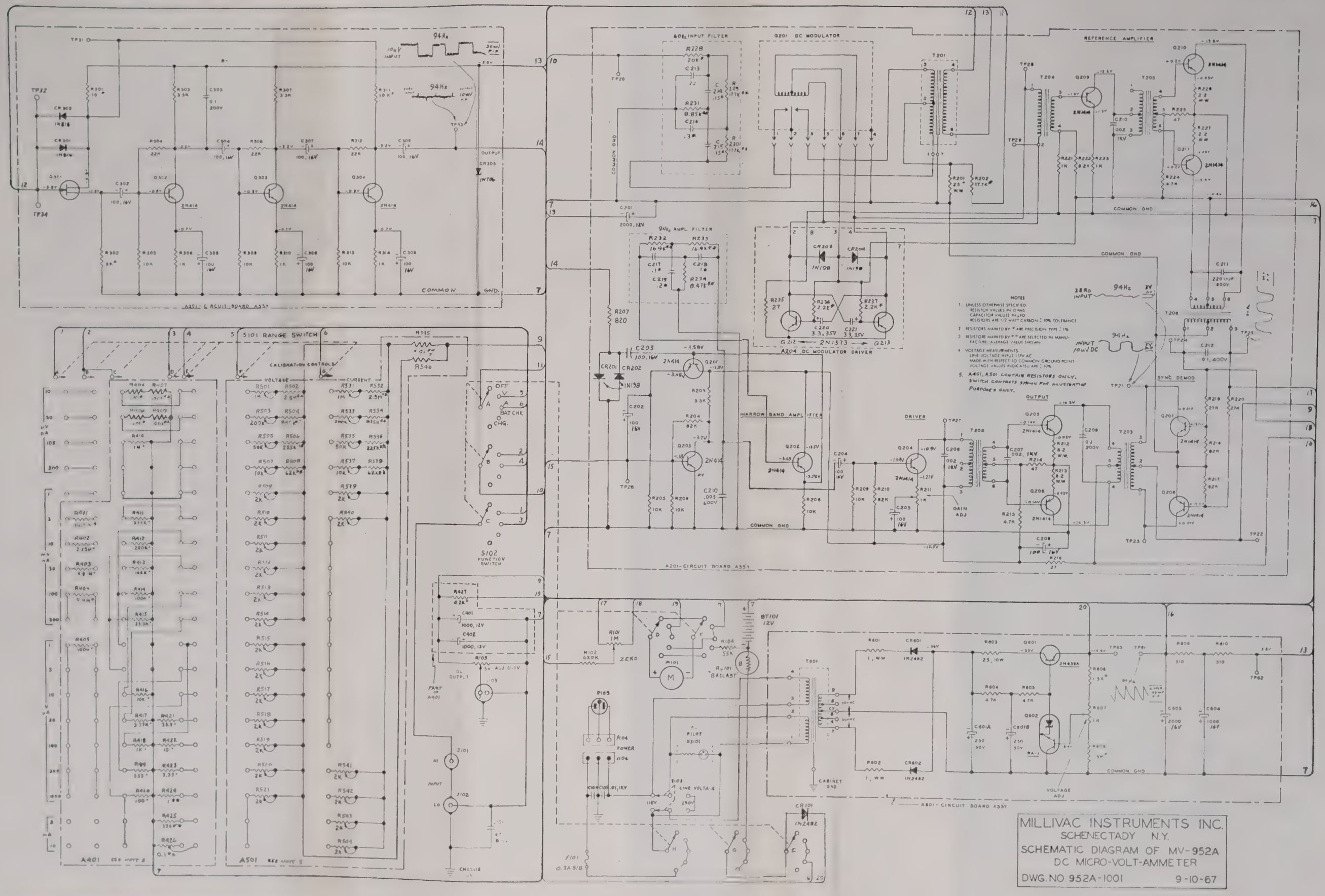
CKT SYM	Description	Manufacturer & Millivac Part No. Mfr's. Part No.
R302	Resistor, fxd, metal film 5K ±1%, 1/4W	512-5001
R303	Same as R203	
R304	Resistor, fxd, comp., 22K ±10%, 1/2W	500-223
R305	Same as R205	
R306	Same as R221	
R307	Same as R203	
R308	Same as R304	
R309	Same as R205	
R310	Same as R221	
R311	Resistor, fxd, metal film, 10K ±1%, 1/4W	512-1002
R312	Same as R304	
R313	Same as R205	
R314	Same as R221	
R315 thru R400	Not assigned	
R401	Resistor, fxd, metal film, 667K ±1%, 1/4W	512-6673
R402	Resistor, fxd, carbon film, 2.25M ±1%, 1/4W	518-2254
R403	Resistor, fxd, carbon film, 4.8M ±1%, 1/2W	520-4804
R404	Resistor, fxd, carbon film, 9.9M ±1%, 3/4W	519-9904
R405	Resistor, fxd, metal film, 100M ±1%, 2W	542-1006
R406	Resistor, fxd, metal film, 1Meg ±1%, 1/4W	512-1004
R407*	Resistor, fxd, metal film, 150K ±1%, 1/4W	512-1503
R408	Same as R406	
R409*	Resistor, fxd, metal film, 48K ±1%, 1/4W	512-4802
R410	Same as R406	
R411	Resistor, fxd, metal film, 333K ±1%, 1/4W	512-3333
R412	Resistor, fxd, metal film, 250K ±1%, 1/4W	512-2503
R413	Resistor, fxd, metal film, 166K ±1%, 1/4W	512-1663
R414	Resistor, fxd, metal film, 100K ±1%, 1/4W	512-1003
R415	Resistor, fxd, metal film, 33.3K ±1%, 1/4W	512-3331
R416	Resistor, fxd, metal film, 10K ± 1%, 1/4W	512-1002
R417	Resistor, fxd, metal film, 3.33K ± 1%, 1/4W	512-3331
R418	Resistor, fxd, metal film, 1K ±1%, 1/4W	512-1001
R419	Resistor, fxd, metal film, 333Ω ± 1%, 1/4W	512-3330
R420	Resistor, fxd, metal film, 100Ω ±1%, 1/4W	512-1000
R421	Resistor, fxd, metal film, 33.3Ω ±1%, 1/4W	512-33R3
R422	Resistor, fxd, metal film, 10Ω ±1%, 1/4W	512-10R0
R423	Resistor, fxd, WW, 3.33Ω ±1%, 1/4W	508-3R30
R424**	Resistor, fxd, WW, 1Ω ±1%, 1/4W	508-1R0
R425**	Resistor, fxd, WW, .333Ω ±10%, 1/2W	507-R333
R426**	Resistor, fxd, WW, 0.1Ω ±10%, 1/2W	507-R10
R427**	Resistor, fxd, metal film, 4.2K ±1%, 1/4W	512-4201
R428 thru R500	Not assigned	

*Resistor may be shunted by another resistor; value selected in manufacture.
**Selected in manufacture; nominal value listed.

CKT SYM	Description	Millivac Part No.	Manufacturer & Mfr's Part No
R501	Resistor, variable carbon, lin. taper, 1M ±30%, 1/4W	580-1053	
R502**	Resistor, fxd, carbon film, 2.5M ±1%, 1/4W	518-2504	
R503	Resistor, variable carbon, lin. taper, 200K ±30%, 1/4W	580-1050	
R504**	Resistor, fxd, metal film, 845K ±1%, 1/4W	512-8453	
R505	Resistor, variable carbon, lin. taper, 50K ±30%, 1/4W	580-1021	
R506**	Resistor, fxd, metal film, 225K ±1%, 1/4W	512-2253	
R507	Resistor, variable carbon, lin. taper, 10K ±30%, 1/4W	580-1049	
R508**	Resistor, fxd, metal film, 62K ±1%, 1/4W	512-6202	
R509 thru R521	Resistor, variable carbon, lin. taper, 2K ±30%, 1/4W	580-1051	
R522 thru R530	Not assigned		
R531	Same as R501		
R532**	Same as R502		
R533	Same as R503		
R534**	Same as R504		
R535	Same as R505		
R536**	Same as R506		
R537	Same as R507		
R538**	Same as R508		
R539 thru R544	Same as R509		
R545** & R546**	Resistor, fxd, metal film, 9K ±1%, 1/4W	512-9001	
R547 thru R600	Not assigned		
R601	Resistor, fxd, WW, 1Ω ±10%, 1/2W	510-1R0	
R602	Same as R601		
R603	Resistor, fxd, WW, 25Ω ±10%, 10W	560-1002	
R604 & R605	Same as R215		
R606	Resistor, fxd, metal film, 1.5K ±1%, 1/4W	512-1501	
R607	Same as R211		
R608	Same as R606		
R609	Resistor, fxd, comp., 510Ω ±10%, 1/2W	500-511	
R610	Same as R609		
R_T1 thru R_T100	Not assigned		
R_T101+	Lamp, 'Ballast'	110-3003	CM239
S1 thru S100	Not assigned		
S101	Switch, rotary, RANGE	410-1024	
S101	Switch, rotary, Range (complete ass'y)	420-1024	
S102	Switch, rotary, Function (MV-852A)	410-1025	
	Switch, rotary, Function (MV-952A)	410-1026	

** Selected in manufacture; nominal value listed.
+ Used in Model MV-952A only.

CKT SYM	Description	Millivac Part No.	Manufacturer & Mfr's. Part No.
S102	Switch, rotary, Function (complete ass'y) (MV-852A)	420-1025	
	Switch, rotary, Function (complete ass'y) (MV-952A)	420-1026	
S103	Switch, slide D.P.D.T.	400-1015	
T1 thru T200	Not assigned		
T201	Transformer, input, Chopper	300-3001	Triad G22
T202	Transformer, interstage	300-2008	
T203	Same as T202		
T204	Transformer, input	300-2007	
T205 & T206	Same as T202		
T207 thru T600	Not assigned		
T601	Transformer, power	300-4010	
	Miscellaneous		
	Cap, shorting	800-7020	Amphenol CW159/U
	Fuseholder	800-2100	Bus HKP
	Knob, bar, w/skirt, RANGE	800-4128	Buckeye PS-95BL-S2
	Knob, Function Switch	800-4127	Buckeye PS-70PL-2
	Knob, ZERO	800-4126	Buckeye PS-70D-2
	Test Lead Set (2)	UG-201	
	Test Lead Set	CL-102	


A201 - CIRCUIT BOARD ASSY
A501 - CIRCUIT BOARD ASSY
A801 - CIRCUIT BOARD ASSY
A401
A501
S101 RANGE SWITCH
CALIBRATION CONTROLS
VOLTAGE
CURRENT
S102 FUNCTION SWITCH
60Hz INPUT FILTER
94Hz AMPL FILTER
G201 DC MODULATOR
A204 DC MODULATOR DRIVER
REFERENCE AMPLIFIER
NARROW BAND AMPLIFIER
DRIVER
SYNC DEMOD
COMMON GND
CHASSIS GND
CABINET GND
ZERO
VOLTAGE ADJ
GAIN ADJ
BALLAST
NOTES
1. UNLESS OTHERWISE SPECIFIED RESISTOR VALUES IN OHMS CAPACITOR VALUES IN µFD RESISTORS ARE 1/2 WATT CARBON ± 10% TOLERANCE
2. RESISTORS MARKED BY * ARE PRECISION TYPE ± 1%
3. RESISTORS MARKED BY ** ARE SELECTED IN MANUFACTURE. AVERAGE VALUES SHOWN
4. VOLTAGE MEASUREMENTS LINE VOLTAGE INPUT 117V AC MADE WITH RESPECT TO COMMON GROUND POINT VOLTAGE VALUES INDICATED ARE ± 10%
5. A401, A501 CONTAIN RESISTORS ONLY. SWITCH CONTACTS SHOWN FOR ILLUSTRATIVE PURPOSES ONLY.
MILLIVAC INSTRUMENTS INC.
SCHENECTADY N.Y.
SCHEMATIC DIAGRAM OF MV-952A
DC MICRO-VOLT-AMMETER
DWG. NO. 952A-1001
9-10-67

GUARANTEE

Millivac Instruments, Inc. guarantees each instrument manufactured by us to be free from defects in material and workmanship for a period of one year from date of delivery to the original purchaser. Repairs during this time will be made by us free of charge, but transportation charges both ways will be borne by the customer.

Excluded from this guarantee are tube and transistor replacements, as well as all damages caused by, or related to, abuse of the instrument either electrically or mechanically. In this case, repairs will be billed at cost and an estimate will be submitted for your approval before the work is started.

If an instrument is believed to be defective, please notify our Service Department, giving the model number and serial number of the instrument, as well as describing the nature of the trouble. Our Service Department will then, if necessary, authorize the return of the instrument under the terms of this guarantee and advise how shipment should be made.

CLAIM FOR DAMAGE IN SHIPMENT

If, on receipt, the shipping cartons appear to be crushed or torn, as evidencing rough treatment, a notation should be made on the carrier's delivery receipt indicating this condition.

As each item is opened, it should be inspected to ascertain that no damage has been incurred during shipment. If no damage is visible, operational checks should be performed to make sure that the equipment arrives in its original operating condition. If any damage is revealed, a claim should be filed immediately with the carrier, stating the extent of the damage. A copy of this report should be forwarded to us along with the model and serial number of the instrument. Millivac will then advise how the instrument should be returned for repair or replacement.

SHIPPING INSTRUCTIONS FOR RETURNS TO FACTORY

No instrument should be returned to the factory without prior authorization from Millivac Instruments, Inc. or our authorized representative.

Shipping instructions will be given at the time return of an instrument is authorized. In all cases the instrument should be packed in a strong container and surrounded by sufficient shock-absorbing material.

INTERPLANT OFFICE SUPPLIES CENTER
B-3 (1-78)